PATENT ABSTRACTS OF JAPAN

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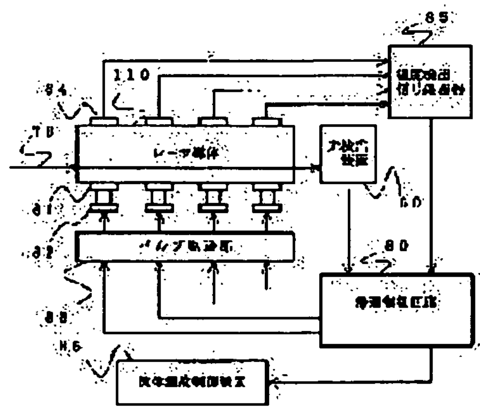
(71)Applicant : SAIFASHA:YUGEN
(72)Inventor : GOTO TETSUO

(54) SOLID LASER

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a stable high-output laser beam of good quality at low cost.
SOLUTION: A fluid is flowed on at least one flow path 81, which comes into contact with the whole side surface (the end surface in the widthwise direction of a slab laser medium 110) of the slab laser medium 110 being held by an excitation chamber and has a substrate, and the quantity or speed of the fluid is adjusted by an adjusting valve 82 by a control of a valve driving part 83 to uniformize a temperature distribution in the widthwise direction of the section of the medium 110. The generation of a heat lens effect and a heat birefringence effect in the interior of the medium 110 is suppressed. As this result, the actuation of the whole medium 110 can be efficiently performed. The driving part 83 is controlled by a feedback control circuit 80 which properly processes a signal on the basis of optical information outputted from a photodetection unit 60 by monitoring the direction of transmitted light, the intensity distribution of the transmitted light, a change in polarized light and the like by a laser beam 70 for detection or on the basis of temperature information outputted from a temperature detection signal treater 85 by treating a detected signal detected by a temperature sensor 84 corresponding to the flow path 81 by the treater 85.



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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention It is related with the solid-state-laser equipment which has the excitation chamber which contained the laser medium of the shape of slab which makes an excitation side two flat surfaces parallel to a X-Z flat surface to the cross direction (X shaft orientations) and the thickness direction (Y shaft orientations) which the rectangle cross section which cuts perpendicularly and is obtained to the propagation direction (Z shaft orientations) of a laser beam has. It is related with the solid-state-laser equipment which can obtain the laser beam of the quality stable high power cheaply especially in the case of an oscillation or magnification.
[0002]
[Description of the Prior Art] Conventionally, there is YAG laser equipment with which the laser medium which made neodium (Nd) ion contain was used during the YAG (yttrium aluminum garnet) crystal among this kind of the fixed laser equipment, and YAG laser equipment with a wavelength of 1 micrometer is widely put in practical use by industrial use.
[0003] However, when applying to metaled welding, cutting, etc. with YAG laser equipment, it is difficult to obtain the big average output of several kW required in order to obtain practical working speed. That reason is that this excitation light is absorbed and heat occurs inside since optical pumping of the YAG crystal is carried out from a perimeter by the lamp light or the laser beam.
[0004] Consequently, the thermooptic effect by the temperature gradient and stress distribution which are produced inside a crystal acts, and refraction of a laser beam or the dissolution of polarization is caused. Therefore, in order to obtain high power, when reinforcement of optical pumping is enlarged, the optical system which compensates sufficient refrigeration capacity and a sufficient thermooptic effect is required.
[0005] In recent years, the YAG laser equipment in which confine a laser beam in the interior and a zigzag optical path is made to form arrived at the region of utilization using the laser medium 110 of a slab mold as shown in drawing 12 .
[0006] The laser medium 110 of the slab mold currently illustrated is a transparent crystalline optically [the plate which makes a Y-axis the thickness direction and makes the X-axis the cross direction to the die-length direction which is the thing of the configuration generally adopted and is the Z-axis]. That is, to the cross direction (X shaft orientations) and the thickness direction (Y shaft orientations) which the rectangle cross section which cuts perpendicularly and is obtained to the propagation direction (Z shaft orientations) of a laser beam has, the laser medium 110 makes two flat surfaces parallel to a X-Z flat surface the excitation side 113, and makes the end face in the two cross direction parallel to a Y-Z flat surface a side face 114.
[0007] Moreover, the laser medium 110 has the optical ON outgoing radiation side 111,112 which makes a flat surface [parallel to the X-axis and] slanting to a Y-axis and the Z-axis by the apical surface of both to the die-length direction (Z shaft orientations) which is the propagation direction of the laser beam 120 excited. When the laser beam 120 parallel to the Z-axis carries out incidence by gamma

whenever [incident angle] to the optical ON outgoing radiation side 111, therefore, the laser beam 120 of the interior which carried out incidence so that it may be illustrated For the optical refractive index of the laser medium 110, while being refracted in the thickness direction (Y shaft orientations), the zigzag optical path which makes the excitation side 113 of two parallel X-Z flat surfaces perpendicular to Y shaft orientations a total-internal-reflection side, and carries out total reflection is formed, and outgoing radiation is carried out in parallel with the Z-axis from the optical ON outgoing radiation side 112.
[0008] With this structure, since it is formed in parallel [a zigzag optical path] with a Y-Z flat surface while a temperature gradient occurs in Y shaft orientations inside the laser medium 110 by absorbing the excitation light supplied through the excitation side (X-Z flat surface) 113, it has the outstanding property that the thermooptic effect mentioned above is compensated. Furthermore, since the cooling surface area of the excitation side 113 which forms the total-internal-reflection side which is a X-Z flat surface by enlarging a crosswise (X shaft orientations) dimension becomes large, the excitation light of large reinforcement is acceptable. Therefore, this structure is suitable for obtaining high power.
[0009] Next, the laser medium of the slab mold mentioned above is explained with reference to drawing 13 from the optically pumped laser indicated by JP,2-246388,A about a conventional example to the internal structure of the excitation chamber stored in the interior, and the passage of cooling water.
[0010] As shown in drawing 13 , the laser medium 210 which is a slab crystal is correctly held in an orientation inside a cassette 222 through elastic body tools 221 like silicone rubber, in order to avoid the effect of external force. Moreover, the elastic body tools 221 holding the laser medium 210 of a crystal bear the role which closes the cooling water 230 which cools the laser medium 210 to coincidence. Moreover, optical pumping of the laser medium 210 is carried out to the double-sided excitation side 213 through the translucent plate 223 according the excitation light in which an excitation lamp emits light to a glass plate or a sapphire plate.
[0011] Therefore, cooling water 230 also cools an excitation lamp and a reflecting mirror 224 to coincidence by making into passage the perimeter of the reflecting mirror 224 which forms the optical path of the excitation lamp (illustration abbreviation) which emits excitation light, and excitation light while cooling the laser medium 210 by making the gap 231 of the excitation side 213 and a translucent plate 223 into passage. The translucent plate 223 also has the duty which protects the laser medium 210 from damage by the fragment of an excitation lamp, when an excitation lamp breaks, while forming the passage of cooling water. Moreover, to the cross direction (X shaft orientations), the flow direction of a field is set [in / to the die-length direction (Z shaft orientations) of the excitation side 213 of the laser medium 210 / both sides / in the flow direction of the cooling water 230 which flows a gap 231 / the same direction or the excitation side 213] up so that the field of another side may be an opposite direction.
[0012] Inside, the laser medium 210 which receives optical pumping and cooling through the excitation side 213 with structure which was mentioned above serves as the maximum temperature in the core of a slab configuration, and generates the temperature distribution which have the configuration of the parabola which decreases in proportion to the square of the distance of the thickness direction (Y shaft orientations) from a core. Namely, a temperature gradient arises in the thickness direction (Y shaft orientations).
[0013] However, in the thickness direction (Y shaft orientations) mentioned above, when the temperature distribution which have parabolic are not [crosswise (X shaft orientations)] uniform, the laser beam to spread receives a thermal lensing effect in a X-Z flat surface. Therefore, the heat insulator 225 intercepted thermally is stuck and formed in the side face 214 in which an interface is made, at the Y-Z flat surface perpendicular to the X-axis. Since thermal resistance is high as the quality of the material and the quality of the material with a large reflection factor is required from excitation light, ceramic material etc. is used for the heat insulator 225.
[0014] On the other hand, since the gain of a laser medium is large in strong pulse excitation, if the spontaneous emmision light generated in the laser medium 210 is reflected with the above-mentioned heat insulator 225, it will be amplified further and, finally will result in parasitic oscillation. In this case, the energy which must have been stored into the laser medium by excitation will be lost. Consequently,

the output of the original laser beam which should be made to oscillate or amplify declines. Therefore, since a laser beam and spontaneous emmision light with the same wavelength are made to absorb in the interface of a heat insulator and the side face of a laser medium as alternatively as possible, the absorber to spontaneous emmision light may be fused and stuck on the side face mentioned above as edge cladding.

[0015] Furthermore, an example of the thermal protection structure of the slab mold solid state laser indicated by JP,8-18128,A is explained with reference to drawing 14 .

[0016] As shown in drawing 14 , in the side face 314 which is an end face of the cross direction of the laser medium 310, the heat transfer member 321 of the heat insulation member 322 which can pass heat and to which it was stuck which becomes an outside field from a right heat conductor further is installed. While the cooling water which contacts the excitation side 313 and cools the laser medium 310 in this structure prevents an extremes-of-temperature rise [/ near / side-face 314 (faying surface with the heat insulation member 322) / the laser medium 310], in order to avoid the thermal expansion of the excitation side 313 in about 314 side face Forming the exposure to which cooling water contacts the both-ends lateral portion in the cross direction of adjusting the thickness of the heat insulation member 322 and the heat insulation member 322 further stuck to the side face 314 of the laser medium 310 or one edge lateral portion is proposed.

[0017] As everyone knows, since the rate of surface area to the volume can take the large advantage in the laser medium of a slab mold as compared with a rod mold, its exhaust heat capacity is high, I hear that it is possible in giving a bigger excitation input, and can take out high power, and there is. Moreover, in the zigzag optical path which repeats total reflection inside a laser medium, since the thermal lensing effect in the field of zigzag does not arise, it is expected that the quality of a laser beam will not deteriorate in high power actuation.

[0018] However, the include-angle breadth of the laser beam actually oscillated from the optical resonator equipped with the laser medium of a slab mold changes with the increment in an excitation electrical input, and as compared with the include-angle breadth of the thickness direction (Y shaft orientations), especially change of crosswise (X shaft orientations) include-angle breadth is remarkable, and is in the inclination of an increment. On the other hand, in a high excitation electrical input, when making an input increase to the inside of a short time, an output increases, but by the time it reaches a thermal equilibrium state after fixing this input subsequently, a laser beam output will decrease and will be stabilized with implementation of a thermal equilibrium state. This phenomenon is known as saturation of an output. In this condition, the pattern of the laser beam outputted from a stabilization mold optical-resonator output mirror on the strength serves as the shape of a spindle shape to which the reinforcement of the part near a side face fell from the rectangle configuration of the X-Y cross section of a laser medium. In the spindle-formed cross section, naturally, since it is smaller than the rectangle cross section of a laser medium, an output declines.

[0019] It is because the laser beam which a temperature gradient produces that reason from the side face crosswise [both] (X shaft orientations), toward the core of slab since the cross direction (X shaft orientations) of the laser medium of a slab mold is limited, consequently progresses in the die-length direction (Z shaft orientations) is refracted in a field parallel to a X-Z flat surface according to a thermal lensing effect and it emits or collects to the medial axis of a laser beam.

[0020] Therefore, in a high excitation electrical input, it separates from the laser beam which penetrates the part of the laser medium near a side face from the oscillation mode in an optical resonator, and the mode volume which can be oscillated decreases. Since the energy which can be taken out outside is by mode volume even if it accumulates energy in the interior of a laser medium with much trouble when the mode volume which can be oscillated decreases, the extraction efficiency of energy falls. In the case of high power, this becomes remarkable especially.

[0021] In spite of having been close to the side face crosswise [both] (X shaft orientations) and having arranged the heat insulator, the cause which a temperature gradient produces is because a heat insulator is not a perfect reflector to excitation light, so surface temperature rises highly by absorbing excitation light on the front face adjacent to a side face. Therefore, a laser medium side will be heated from a side

face. Moreover, since the excitation light reflected from the reflective spot on a heat insulator or the side face of a laser medium has include-angle breadth, the absorption excitation reinforcement per unit volume increases near the side face as the average. Consequently, it multiplies by heating from a heat insulator, and a temperature gradient occurs.

[0022] An example about the situation of a temperature gradient is shown in